Remarks

Applicants respectfully request that this amendment be entered, and that their subject U.S. Patent application be passed to issuance in view thereof. The foregoing amendments are further indicated in blackline form in Exhibit A, "VERSION WITH MARKINGS TO SHOW CHANGES MADE."

In the Office Action, claims 1-3 and 6 stand rejected as being obvious in view of U.S. Patent 5,290,732 ("Kumar") and U.S. Patent 5,674,787 ("Zhao"). Note that in Kumar, the structure 14A is an aluminum line (c.f. Col. 3, lines 20-21; Col. 5, line 33), 18A is a barrier layer, 40 is a first metallic bump, and 44 is a second metallic bump. Zhao's Fig. 6 has a first layer of copper 11, a first barrier layer 13, a second layer of copper 23, and a barrier layer 24. The barrier layer is nickel, cobalt, or alloys based thereon (c.f. Col. 8, lines 10-15), that are taught as serving as a diffusion barrier (c.f. Col 8, lines 30-31).

The Examiner suggests that this combination of references teaches the invention. In doing so the Examiner suggests that a person of ordinary skill in the art would apply the teachings of the copper line and copper stud of Zhao as a substitute for the teachings of the Al line and first metallic bump of Kumar. However, Applicants respectfully submit that this combination does not reflect the teachings of the respective references. First, Applicants respectfully submit that these are two different structures. The Kumar teachings are for a bump pad, the Zhao teachings are for an integrated stud and line that is not constructed for the purpose of providing a pad for a solder bump. Specifically, Zhao does not teach or suggest optimizing the barrier layer 24 to serve as a bump surface for a solder ball, while Kumar teaches the need for compatibility between the first bump 40 and the second 44 (and with good reason - the first bump 40 must provide a sufficient wetting surface for the second bump 44). As such, Applicants respectfully submit that a person of ordinary skill in the art, absent teachings provided by the present application, would not make the combination of references as proposed by the Examiner.

Moreover, even if a person of ordinary skill in the art was somehow motivated to make the suggested combination, note again Zhao teaches the inclusion of a diffusion barrier above the

second layer of copper. The teaching of the diffusion barrier is key to the overall teachings of Zhao; specifically, the patent says "[s]ince copper diffuse/drift (sic, diffuses/drifts) easily in inter-level-dielectric (ILD) materials, copper interconnect structures must be encapsulated by diffusion barrier layers...Typically, the use of diffusion barrier material to encapsulate copper is not limited to the copper-ILD interface, but also to interfaces with other metals as well. Thus, copper encapsulation techniques are also used to isolate copper interconnect structures....from overlying metal layers where these metal layers are formed from other than copper..." (Col. 2, lines 8-29; see also Col. 8, lines 8-31). Thus, a person of ordinary skill in the art, in making this combination, would apply both the copper plug 23 and the barrier 24 of Zhao to Kumar's teachings. As such, this combination neither teaches nor suggests the invention. In the invention as shown in Fig. 2, the solder ball 25 is disposed directly on the copper layer 24; the point of the copper layer immediately below the solder ball is to consume impurities, not to be protected from them (c.f. page 10, lines 2-7 of the present specification). Copper layer 24 is used for this purpose because it is the same material as underlaying copper layer 20; by it very nature, it will consume the same impurities that would be problematic for the underlaying copper 20, because it is the same material. As such, Applicants respectfully submit that this combination of references teaches away, rather than toward, the invention, in that it teaches copper applications in which copper is isolated from potential contaminants, not used to help consume them. Applicants have amended their claims by canceling claim 1 and incorporating its limitations into claim 6, and drawing the dependency of claims 2 and 3 to claim 6. Applicants respectfully submit that the rejections of record to claims 1-3 and 6 have been traversed.

As to the rejections of record to claims 4 and 7, applicants have amended these claims to now depend on claim 6 as discussed above. Since the combination of references applied to claims 4 and 7 is further based on the Kumar-Zhao combination discussed above, and since they depend on a claim that distinguishes from this combination, Applicants respectfully submit that these dependent claims 4 and 7 are patentable over this combination. Further, Applicants respectfully submit that neither the Chang et al reference (USP 5,048,744) nor the Havemann reference (USP 6156651) teach or suggest structures that would address the shortcomings of the Kumar-Zhao combination as discussed above. Chang et al simply teaches different barrier layers. In Havemann, whenever a copper metallization is utilized, note it is capped with either a conductive

barrier layer (note e.g. the front figure of the patent, copper 26 is capped by TiN layer 28) or a nonconductive encapsulant layer (note e.g. copper 52 is capped with a silicon nitride encapsulant 54). In all cases, Havemann teaches utilizing protective layers that prevent impurities from penetrating into the copper. Again, note that in the invention the point of the copper layer immediately below the solder ball is to consume impurities, not to be protected from them. As such, Applicants respectfully submit that Havemann teaches away, rather than toward, the invention, in that it teaches copper applications in which copper is isolated from potential contaminants, not used to help consume them. Applicants respectfully submit that the rejections of record to claims 4 and 7 have been traversed.

As to the remaining rejections to claims 8-11 and 13-14, which are based on various combinations of the references discussed above, Applicants respectfully submit that these claims can be distinguished from these references for the same reasons as set forth above. Note that they have cancelled claim 8 and incorporated its limitations into claim 13, and claims 9-11 and 14 have been amended to draw their dependency from claim 13. Applicants respectfully submit that accordingly, the rejections of record to claims 8-11 and 13-14 have been traversed.

Applicants have submitted new claims 22-28. Applicants respectfully submit that these claims do not recite new matter. Applicants further respectfully submit that new claims 22 - 28 recite patentable subject matter. Claim 22 is dependent on claim 13, which was discussed previously. Independent claim 23 specifies that the second layer of copper consumes diffusion species from an overlaying conductor; since the point of the Zhao and Havemann structures is to protect the copper layers from impurities, Applicants respectfully submit that claim 23 (along with claims 24-28 dependent thereon) patentably distinguish from the references of record.

Accordingly, Applicants respectfully request entry of the present Amendment and passage of their subject application to issuance in view thereof. Should the Examiner have any comments, questions, or suggestions, please do not hesitate to contact the undersigned attorney at the telephone number and/or email address set forth below.

Respectfully submitted,
For: Howell et al.

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Exhibit A

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Claims:

Cancel claim 1 in its entirety.

2. (Amended) The metallurgical structure in claim 6 [1], wherein said same material comprises copper.

3. (Amended) The metallurgical structure in claim 6 [1], wherein said barrier layer comprises one or more layers of Ti, TiN, Ta, and TaN.

4. (Amended) The metallurgical structure in claim 6 [1], wherein said barrier layer and said metal plug prevent elements within said solder bump from diffusing to said metal line.

6. (Thrice Amended) [The metallurgical structure in claim 1] A metallurgical structure comprising:

a passivation layer;

a via through said passivation layer extending to a metal line within said metallurgical structure;

a barrier layer lining said via;

a metal plug in said via above said barrier layer, wherein said metal plug and said metal line comprise a same material, and wherein said metal plug, said barrier layer and said passivation layer form a planar exterior surface of said metallurgical structure; and

a solder bump formed on said planar exterior surface;

wherein said solder [ball] bump is in direct contact with said metal plug.

7. (Amended) The metallurgical structure in claim 6 [1], further comprising a second barrier layer above said metal plug and a second metal plug above said second barrier layer, said second metal plug being in direct contact with said solder [ball] bump.

Cancel claim 8 in its entirety.

9. (Amended) The integrated circuit structure in claim 13 [8], wherein said same material comprises copper.

10. (Amended) The integrated circuit structure in claim 13 [8], wherein said barrier layer comprises one or more layers of Ti, TiN, Ta, and TaN.

11. (Amended) The integrated circuit structure in claim 13 [8], wherein said barrier layer and said plug prevent elements within said connector from diffusing to said components.

13. (Thrice Amended) [The integrated circuit structure in claim 8] An integrated circuit structure comprising:

internal components within an exterior covering;

a via extending through said exterior covering to said internal components;

a barrier layer lining said via;

a plug in said via above said barrier layer, wherein said plug and said internal components comprise a same material, and wherein said plug and said barrier layer form a planar exterior surface of said integrated circuit structure; and

a solder bump connector formed on said planar exterior surface;

wherein said solder bump connector is in direct contact with said plug.

14. (Amended) The integrated circuit structure in claim 13 [8], further comprising a second barrier layer above said plug and a second plug above said second barrier layer, said second plug being in direct contact with said solder bump connector.

Please add new claims 22-28, as follows:

22. The integrated circuit structure of claim 13,, wherein said solder bump connector is comprised of a lead/tin alloy.

23. A metallurgical structure, comprising:

a first layer of copper on a substrate;

a barrier layer on said first layer of copper;

a second layer of copper formed on said barrier layer; and

a conductive structure that includes a given species, at least some of said given species diffusing from said conductive structure, said second layer of copper having a thickness sufficient to at least partially consume said species diffusing from said conductive structure, and to adhere to said conductive structure.

24. The structure of claim 23, wherein said conductive structure comprises a solder ball.

25. The structure of claim 24, wherein said given species comprises tin.

26. The structure of claim 24, wherein said solder ball comprises a lead/tin alloy.

27. The structure of claim 24, wherein said barrier layer is selected from the group consisting of Ti, TiN, Ta, Tan, and combinations thereof.

28. The structure of claim 24, wherein said second layer of copper has an upper surface that is substantially coplanar with surrounding insulative structures.